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Riverbank Erosion and Rural Food Security in Bangladesh

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Abstract: The erosion of riverbanks has a negative impact on many nations across the world, costing them land, buildings, food, fish, and other living things, which forces people to relocate. Both the frequency and severity of riverbank erosion are alarming in Bangladesh. In Zajira Upazila, a baseline investigation was carried out to evaluate the effects of river erosion on the local availability of food. The results show how erosion threatens the majority of residents in the research territory. Additionally, as a consequence of the depletion of farmland brought on by the disaster and its effects, crop production is steadily dropping. Occasionally, people lose whole properties, leaving them with few employment options and little spending power. As a result, they are always in danger of experiencing a shortage of food. The suffering people use various coping strategies to deal with these challenging circumstances, such as shifting to cheaper or less appealing eating options. Despite the fact that local governing bodies have put in place various programs to help them, including food assistance and social protection programs, these are inadequate because of the government's constrained organizational assets and competence The study's findings will aid scientists and decision-makers in Bangladesh and abroad in better comprehending the requirements of vulnerable riverine populations and in designing programs that would increase those societies' food safety Therefore, these results imply that developing and implementing efficient rural development strategies could increase the food security of those residing in Bangladeshi regions threatened by riverbank erosion.

Keywords: food safety; riverbank erosion; rural development; agriculture; local administration; Bangladesh

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1. Introduction

Bangladesh is increasingly being recognized by the world as a country prone to various natural disasters, such as riverbank erosion, floods, droughts, cyclones and storms [1–4]. These calamities pose a great challenge to the country's sustainability in terms of food security. Approximately 40 million Bangladeshis are food-insecure and 11 million suffer from starvation [5].

The country lies on the Ganges-Brahmaputra-Meghna (GBM) river system's alluvial floodplain along with many of its branches. The catchment area of the Ganges-Brahmaputra-Meghna (GBM) river system is approximately 1.65 million km^2 [6]. The GBM river system

and other waterways carry approximately 1.1 billion tons of sediments annually [6,7]. The GBM river basin has the most significant quantity of silt deposition anywhere on Earth [8–10]. Due to this excess silt, the river system is losing depth, resulting in frequent changes in the alignment of the channels. These natural phenomena are the main cause of fluvial floods and riverbank erosion across the river basins of Bangladesh [11]. Such natural disasters are responsible for the loss of lives and damage to land, biodiversity and infrastructure, causing a significant reduction in agricultural production and adversely affecting the country's food security, especially that of poor people living near the banks of huge river systems [12,13]. For instance, riverbank erosion causes a yearly loss of nearly 8700 ha of homestead in Bangladesh, displacing almost 0.2 million people [14–16]. Due to the low-lying nature of the Bay of Bengal, during the June–September monsoon, rains prevail over Bangladesh and adjacent regions [17], which are responsible for depositing huge amounts of silt on riverbeds. This tendency in the accumulation of silt alters the structural characteristics of the rivers, which intensifies erosion in the basins of the GBM river system [7,18]. Bangladesh is home to the Padma and Jamuna rivers, which are the global rivers Ganges and Brahmaputra's respective downstream channels [19,20]. The Padma and Jamuna combine, increasing the flow of the latter. The riverbank erosion in the Padma basin is greatly accelerated by this combined water flow [21,22]. The basins of Bangladesh's major rivers are severely impacted by riverbank erosion in a variety of ways. The increasing influence of such natural disasters on food production has been a significant challenge for Bangladesh over the last few decades [4,23,24]. Natural disasters including cyclones, floods, droughts, and erosion are expected to have devastating effects on agricultural and food availability in the years to come in many regions of the world, especially in emerging nations like Bangladesh [13,16,25].

Since rice is the primary food in Bangladesh, the achievement or failure of agricultural products and shortages of water in any given year are all considered with the utmost concern. In Bangladesh's total economic development, its agricultural industry is crucial. One of the most defining characteristics of monsoon regions around the world is the periodical variance in rainfall. In Bangladesh, the rainy season lasts for a period of four months, from June to September, with significant regional and seasonal differences [26]. During the non-monsoon season, a countrywide shortage of water is caused by such an elevated level of rainfall. A regular monsoon with equal amounts of rainfall is a blessing, but an excessive occurrence that causes widespread flooding or drought in the entire country or a specific region is an environmental risk. Thus, ensuring the accessibility of sufficient water for watering under altered climatic conditions is crucial for Bangladesh, where cultivation has an important effect on its financial situation and way of life. A reliable supply of water is the primary factor that controls the output of agriculture.

In a nation where there is a shortage of agricultural land, riverbank erosion lowers the overall area of cultivated land each year. For example, Bangladesh has 0.05 hectares of cultivated land per inhabitant. This results in a decrease in aggregate food production and, as a result, has a negative influence on the food and livelihood insecurity of the vulnerable riverine population. The country's internal migration and relocation are frequently caused by erosion. Specifically for those focused on decreasing poverty and hunger, the danger of riverbank erosion is seen as one of the primary barriers preventing Bangladesh from accomplishing its MDGs [27]. SDG 2.1 revealed that by 2030, we must end hunger and ensure access for all people, in particular, the poor and people in vulnerable situations, including infants, to safe, nutritious, and sufficient food all year round (https://www.un.org/sustainabledevelopment/hunger/, accessed on 1 January 2020). Besides, For sustainable development, it is vital to consider the land-river interface (LRI). The natural resources and ecosystem services that are directly connected to numerous Sustainable Development Goals (SDGs) are supported by the environmental processes that determine the LRI [28]. Every year, riverbank erosion affects millions of people by causing damage to and loss of crops, cattle, housing structures, and farmland. It also deteriorates public infrastructure and communication networks. The Padma River's bank lines are very

unstable. Recently, the right bank of the Padma has been threatened by severe erosion, particularly in Zajira Upazila of the Shariatpur district.

In Bangladesh, food security has been a major concern since the country's independence because it is closely related to poverty reduction programs and the prosperity of the citizens. The nation recently achieved food sufficiency, having reduced its poverty rate from 62% in 1988 to 23.2% in 2016. In Addition, a third of households have experienced homestead loss more than three times in the past ten years, and 57% have experienced at least one loss [29]. A clean rice growth rate of 0.34 million tons (MT) per year has been achieved in Bangladesh because of the combined efforts of rice scientists, extension workers, and farmers. By 2050, Bangladesh will have a population of 215.4 million, at which time 44.6 MT of clean rice would be needed [30]. Thus, the multidimensional impacts of riverbed erosion should be explored to ensure the country's food security situation, and effective steps must be taken to improve the socioeconomic condition of the affected rural people [1,4]. Besides, women have great difficulty finding new homes immediately after losing practically everything to the river, in addition to additional work demands, family conflicts, health issues, social neglect, and feelings of insecurity [31]. In this study, the aim was to investigate the impacts of riverbank erosion on the food security of rural households near the Padma River basin and their coping strategies.

Most of Bangladesh's rural people rely on agriculture, which is particularly vulnerable to climate change. Therefore, issues related to global warming in general and the persistent threat of riverbank erosion specifically have an effect on the rural riverine societies in Bangladesh. Global warming impacts are expected to alter the occurrence of overflowing [32,33], raising the erosion danger along rivers [34,35]. Initial and second-order disaster consequences, as well as both direct and indirect risk effects, are often used terms [36]. Riverbank erosion contributes to the annual loss of riverine households' land, homesteads, ponds, crops, trees, and other resources (Figure 1). Their income and work prospects have been reduced as a result of the loss of land and resources. Besides, being homeless, the mental health of riverbank societies is degrading day by day [37] and homeless/displaced persons typically seek shelter in open spaces, embankments, and high land, as seen in Figure 1. Due to these circumstances, the livelihoods of riverine households are in danger. In addition, they will probably see an increase in mean annual temperature brought on by changes in the climate, in addition to unpredictability in rainfall, a possible decline in cereal crop yield, and a rise in the impacts of disease, insects, and weeds on both crops and animals [38,39]. Moreover, poor socioeconomic conditions, sickness, medical costs, and loss of property are just a few of the horrible effects of riverbank erosion [40]. Due to erosion and the presence of rivers nearby, their surroundings are extremely volatile, making them susceptible to flooding. Decreased food allowances for households, especially for small farmers and landless people, are a result of lower food production, poorer employment prospects, and volatile food prices. As a consequence, food scarcity will have the greatest initial impact in a community where a great many households depend on farming, as in our study. To deal with the risks at this time, riverine communities employ a number of adaptation and mitigation strategies (Figure 1).

These techniques for adaptation may be put into practice on individual farms or in a planned fashion (by means of government policy). The fact that not all families are equally impacted by the impacts of climate change and its threats should be emphasized. As a result, how each household responds will depend on its economic condition and the social and political relationships that exist in that community [12,41]. As a result, it is important to include a variety of livelihood possibilities as well as assets for adaptation when evaluating the dependence on agriculture of riverine households and their level of food availability. However, there were several limitations to this study, such as fewer reports from women, environmental difficulties like cyclones, heavy rain, and so on.

This study uses data from cross-sectional surveys to look at how remote riverine families react to such risks alongside additional warming-related problems in order to lessen severe livelihood and food scarcity situations that frequently result in migration and inter-

country movement. Policymakers might concentrate on community adaptation attempts, which are considered essential to lowering food insecurity and improving the livelihoods of poor farmers, by recognizing the fragility of households and tactics for responding [42,43]. Therefore, to improve mental and physiological health and socioeconomic conditions, it is vital to minimize riverbank erosion in Bangladesh. This study will contribute to understanding Bangladesh's riverbank erosion's causes and likely government- and non-government-sponsored solutions.

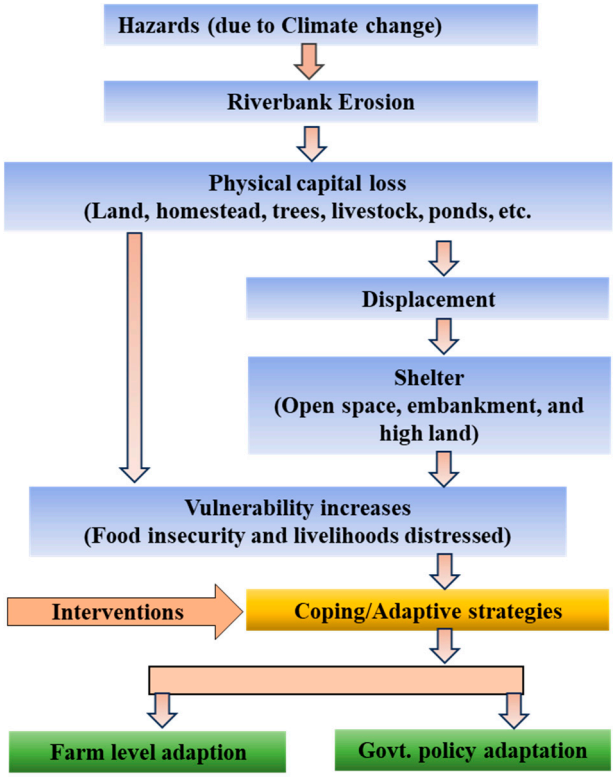


Figure 1. Conceptual framework of the study.

2. Materials and Methods

2.1. Brief Description of the Study Site

The study was conducted in the Zajira sub-district of Shariatpur district, which is 100 km to the southeast of Bangladesh's capital, Dhaka. Zajira is situated to the south of the Padma (Figure 2). The total land area of this sub-district is 246.21 km^2, and its total population is 194,019 (https://en.wikipedia.org/wiki/Zajira_Upazila, accessed on 11 July 2014). The frequency of riverbank erosion is rather high in this region. Most of the people here are involved in agriculture.

Zajira belongs to the Lower Ganges River Floodplain Agro-Ecological Zone. The organic matter content in the soil here is low, which is mainly responsible for its low fertility status [44]. The main agricultural crops in Zajira are rice, oil seed, spices and pulses [35]. Figure 3 shows some images of the lifestyle and eroding riverbanks along the Padma (Zajira) river.

2.2. Primary Data Collection

In the study under discussion, multistage sampling was done to collect both qualitative and quantitative data. We collected primary data for quantitative analysis by number, for example, married or unmarried, family size, and occupation as well. Also, we measured qualitative data through respondents' opinions or assumptions, which include experience, household food, security status, housing condition, education facilities, and so on, regarding riverbank erosion. A personal interview and a questionnaire survey were con-

ducted among the inhabitants of the Padma riverbank and local public representatives in the affected area. Researchers obtained ethical clearance (APD Ethical Clearance Application Number: 1088C) from the University of Reading before starting the field survey. Participants from two unions were interviewed, and a 5% random sampling design was used from 1000 people. The cross-sectional sampling method was applied [1]. A total of 60 villagers and 20 local public representatives were selected for the study on a random basis. Computer-generated numbers were allocated for the questionnaires to ensure a random sampling of the interviewed household heads or members (in the absence of household heads). The enumerators moved to another participant when a respondent was non-responsive, and thus they continued interviewing till the required number of respondents was reached.

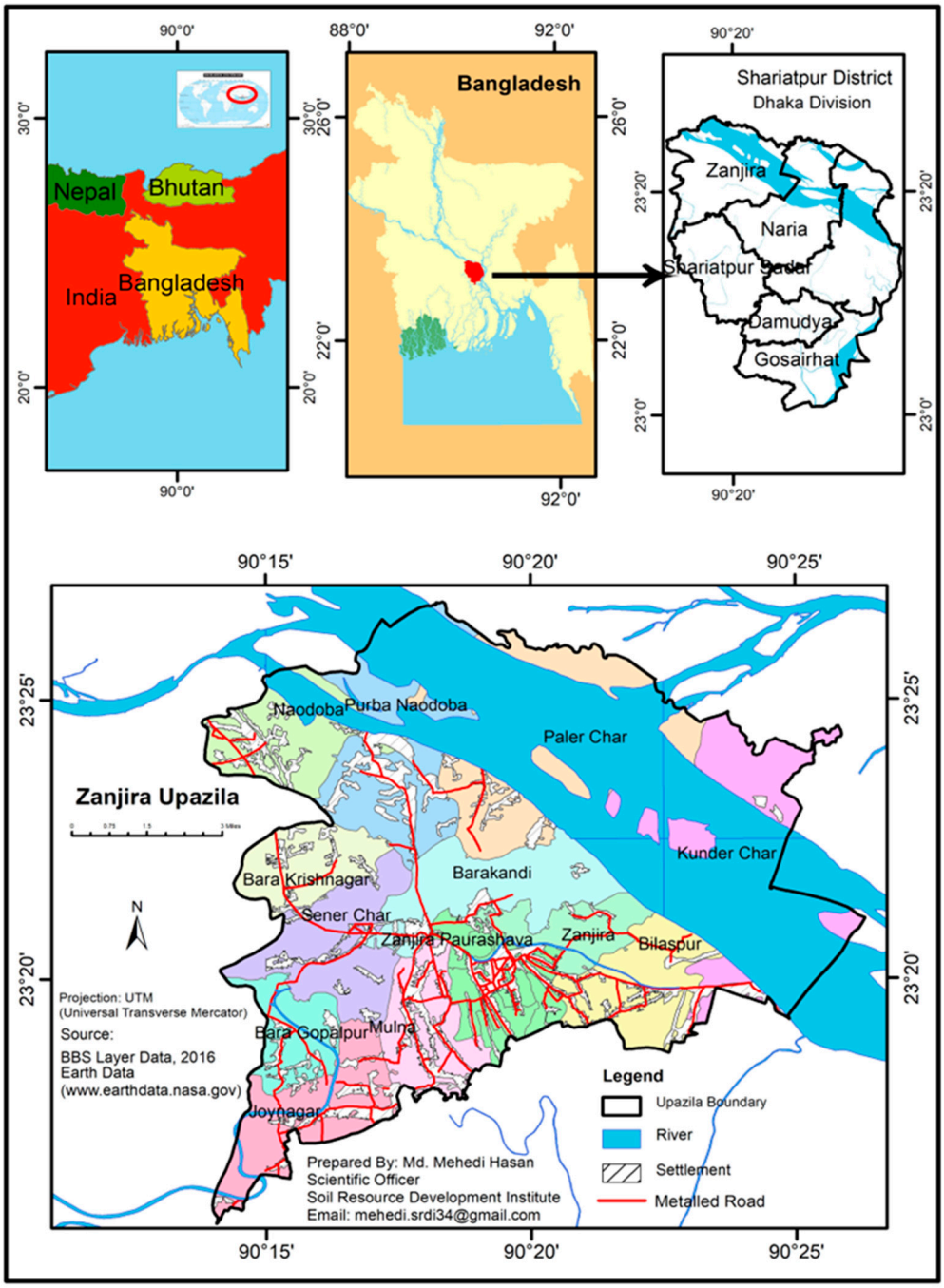


Figure 2. The study area shown in the map of Bangladesh (Source: BBS, 2019).



Figure 3. Riverbank erosion and livelihood in the study areas in Zajira, Sariatpur.

The questionnaire used to conduct the survey was semi-structured and contained a mix of open-ended and closed questions. First, a draft questionnaire was developed based on previous research findings and suggestions of the research supervisor. Before starting the final survey, arrangements were made for pre-testing the draft questionnaire to eliminate any ambiguity in the questions and ensure the collection of accurate and sufficient data. While the questionnaire for the local government representatives had only one section, the questionnaire for the riverbank-erosion-affected people had three sections: Section A covered demographic data, Section B was used to collect information on socioeconomic aspects, and Section C contained questions on riverbank erosion, its impact on the local people and their coping strategies. The enumerators are government servants working at the union level under the supervision of the Upazila (sub-district level) and the Department of Agricultural Extension (DAE) of the government of Bangladesh. The survey and interview of the participants were conducted in August 2019.

2.3. Data Validation

Some techniques were followed to ensure the validity and reliability of the survey, such as developing and finalizing the questionnaires' incomprehensible language. Researchers ensured that all participants understood the questions before starting the interview through Skype, and the research supervisor also briefed them about the questionnaire. Under the research supervisor's guidance, the questionnaires were finalized. All the interviews were audio-recorded with the respondents' consent to ensure the credibility of the interview process. Further, the data provided by the study participants were compared with different reports of relevant research organizations to ensure the validity and reliability of the results.

2.4. Secondary-Data Collection

Secondary data were collected to support the primary data collected from the respondents. The sources for these data were published reports and the websites of different organizations under the Bangladesh government.

2.5. Data Analysis

The data were analyzed using PRIMER v7.0.21 [45] and SPSS v22 software. Using an appropriate scoring technique, the qualitative data were converted into quantitative data wherever necessary. To describe different variables, statistical measures, such as means and number and percentage distributions, were used.

3. Results

3.1. Demographic Details of Respondents

According to demographic features, most of the study respondents were male (90%), and the remaining 10% were female. Moreover, it was found that many of them were middle-aged; those belonging to the age groups of 31–45 years and 46–59 years constituted 31.7% and 33.3% of the participants, respectively. Regarding marital status, it was observed that 95% of them were married, and only the remaining 5% were unmarried. Further, the majority of the respondents (70.0%) had a large family, whereas very few (1.7%) had a small family (Figure 4). These results suggested that the respondents were mature enough and were vulnerable to riverbank erosions.

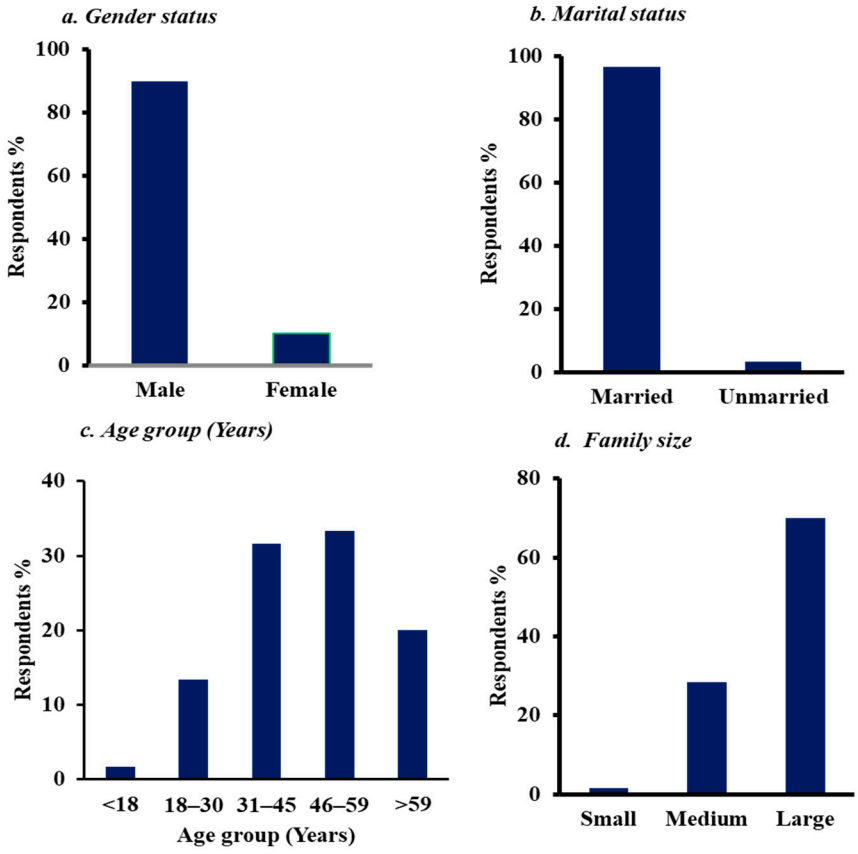


Figure 4. Demographic information of the respondents.

3.2. Agriculture Is the Main Source of Living

The researchers found that the maximum number of participants (71.7%) practiced agriculture as their main occupation, whereas a negligible percentage (1.7%) earned primarily through livestock farming. Regarding land ownership, the majority of the participants (63.3%) reported having land of their own, while 36.7% did not own land. Further, most of the respondents (91.7%) stated that their own products did not fulfill the annual food demands of their families. While 60% of them mentioned they purchased food to satisfy their family's requirements, 35% stated that they received food aid and also purchased food to fulfill their household demands (Figure 5). These results showed that, despite the fact

that agriculture is their primary source of income, they still had to buy food to meet their needs, which might be the result of a decrease in fertile land caused by riverbank erosion.

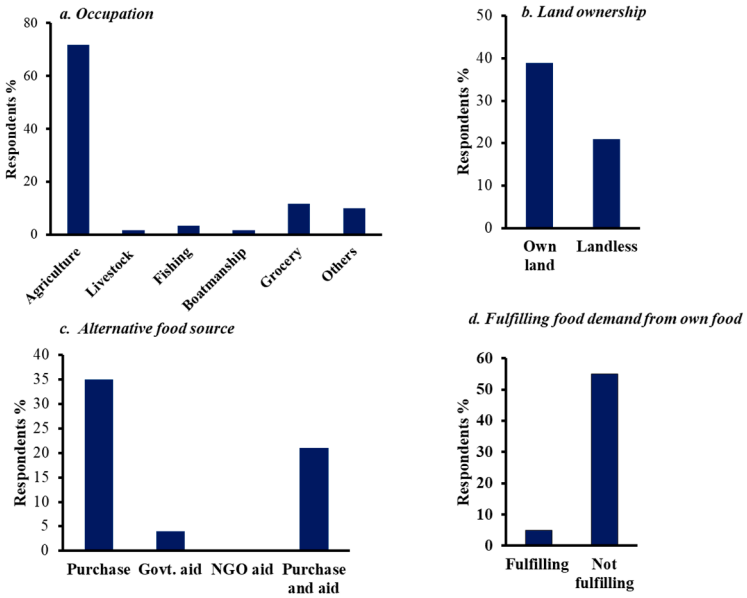


Figure 5. Socioeconomic features of the respondents.

3.3. People Affected Severely by Erosion and Lost Agricultural Products

The first question posed to the local people during their interview was, 'Do you live in the Padma river basin?' All the participants answered in the affirmative. Then, they were questioned about the existence of riverbank erosion in their area. Again, all respondents stated that they observed riverbank erosion in their locality. Approximately 97% of them (Table 1) said that they were affected by riverbank erosion. Despite the fact that riverbank erosion proceeds slowly and progressively year after year, it has long-term and irreversible consequences.

Table 1. Participants' experiences of riverbank erosion and their food security status.

Participants Experience	Response	Percentage
Experience regarding riverbank erosion	Yes	96.7
	No	3.3
	Do not know	0
Experience regarding their household food security status before riverbank erosion	Secure	90.0
	Not secure	6.7
	Not sure/do not know	3.3

The interviewees also provided information about the different types of land eroded. They had lost their cropland. They had also lost ponds, vegetable and fruit gardens and, homesteads, commercial and other lands due to riverbank erosion. The participants' responses are presented in Figure 6. Riverbank spills and erosion are common during the monsoon season in Bangladesh. Riverbank erosion in Bangladesh is mostly caused by the braided character of the rivers, which is exacerbated by excessive rainfall, particularly upstream, and increased water flow. The pace of riverbank erosion has recently accelerated dramatically as a result of climate change, culminating in the unexpected collapse of riverbanks and the devastation of entire Unions and Upazilas.

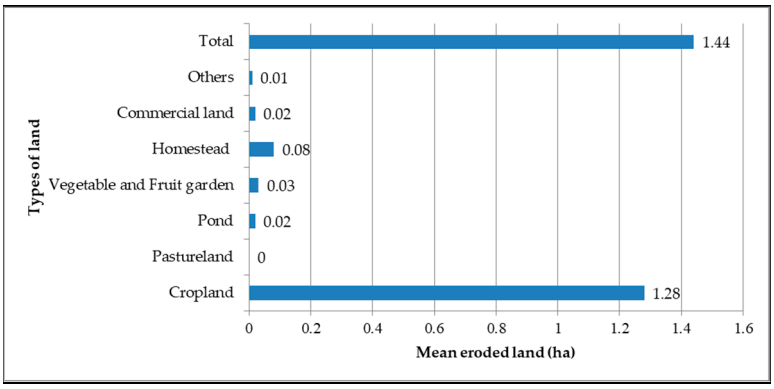


Figure 6. Types of land eroded over the last 20 years in the study area.

3.4. Declined Household Food Security and Livelihood

Regarding household food security, some parameters were used to evaluate the effects of riverbank erosion on the people's lives and livelihoods, such as food shortage, a decline in income sources, disruption in communication, destruction of the homestead, trouble in availing public services and disruption in transportation (Figure 7).

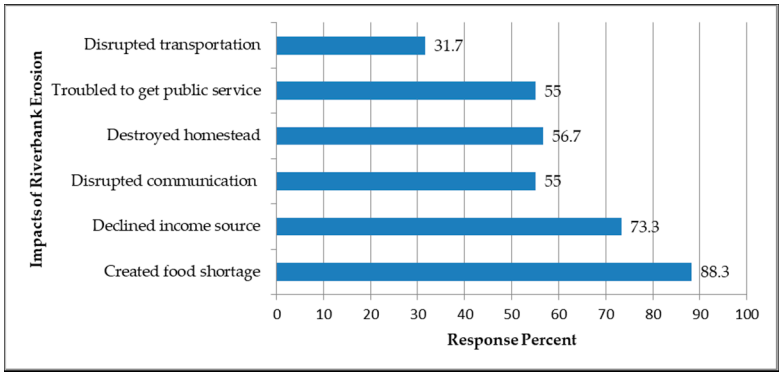


Figure 7. Effects of riverbank erosion on the lives and livelihoods of the affected people.

The majority of the respondents (88.3%) stated that riverbank erosion had caused food shortages in their households, and 73.3% of them mentioned that their income sources had declined due to the disaster (Figure 7). A recently published study found that the loss of agricultural land leads to a decline in total crop yield. However, their research was conducted in Harirampur, Manikgonj district, on the Padma River. Our results were nearly identical to theirs, although the location was different. Their responses to the interview question 'What is your household food security situation throughout the year?' are presented in Table 2. Between January and June, food was secured by around 53% of the respondents, whereas the others mentioned that their household food security was inadequate during that period. In contrast, only 15% of them reported securing food for their households during July–December, while the majority (61.7%) revealed food scarcity.

With respect to household food security, the first question posed was, 'Were members of your household anxious about the lack of sufficient food during the last three months?' Almost 98% of the respondents stated that they were sometimes anxious over the lack of sufficient food during the previous 3 months (Table 3).

The next questions were, 'Were any members of your household—including yourself—forced to go without meals one or more days over the past three months because there wasn't enough food? and "Have you or anyone else in the family gone to bed starving because there wasn't enough food to go around in the past three months?" In both cases, all respondents answered 'No' (Table 3).

Table 2. Household food security status throughout the year.

Time Period	Answer/Category	Responses (%)
January to June	Adequate	53.3
	Inadequate	46.7
	Scarce	0
July to December	Adequate	15.0
	Inadequate	23.3
	Scarce	61.7

Table 3. The situation of household food insecurity perception.

Food Insecurity Status	Answer Category	Response (%)
A. During the past three months, did anyone in your home worry about there not being enough food?	No	1.7
	Yes	98.3
	If yes	
	Most of the time	0
	Sometimes	98.3
	Sudden	1.7
B. Did the lack of enough food during the past three months force you or any other person of your family to consume less than three meals every day?	No	100
	Yes	0
	If yes	
	Most of the time	-
	Sometimes	-
	Sudden	-
C. During the previous three months, did you or any other family members become restless or starving as a result of not having enough of food?	No	100
	Yes	0
	If yes	
	Most of the time	-
	Sometimes	-
	Sudden	-

With regard to the availability of different kinds of food from their own produce, the interviewees mentioned that rice covered the highest period of 2.55 months, followed by milk (1.9 months), whereas meat sustained them for only 0.32 months (Table 4).

Table 4. Availability of different kinds of food self-produced by the respondents.

Types of Food	Average Months Covered	Types of Food	Average Months Covered
Rice	2.55	Pulse	0.76
Wheat	0.38	Spices	0.80
Fish	0.38	Oil	0.57
Meat	0.32	Fruits	0.63
Egg	1.60	Vegetables	1.05
Milk	1.90	-	-

3.5. Riverbank Erosion Damaged Social Life

The impacts of riverbank erosion on social life including housing, health facilities, education, communication and many other parameters were measured through 17 questions (Table 5). The answer options were 'No change' (0), 'Deteriorated' (1) and 'Improved' (2). Most (91.7%) of the respondents stated that their housing conditions had deteriorated due to the disaster. Further, 88.3% of them reported that occupation opportunities for their household members had declined. However, some also mentioned that electricity and health, transport, education and marketing facilities in their area had improved (Table 5).

Table 5. Riverbank Erosion Impacts on Household Indicators.

Items	After Riverbank Erosion (Response %)			Reason
	No Change	Deteriorated	Improved	
Housing condition	3.3	91.7	5.0	I: Business D: Damage to house
Occupation opportunities	3.3	88.3	8.3	I: Small business D: Lack of work, loss of agril. land
Income of the household	10.0	76.7	13.3	I: Migration to the city D: Shortage of work
Education facilities	0	56.7	43.3	I: Migration to the city D: Financial problems, destruction
Health facilities	0	58.3	41.7	I: Migration to the city D: Poor health facilities
Electricity	5.0	53.3	41.7	I: Expansion of electricity D: Destruction of electricity supply
Sources of drinking water	8.3	50.0	41.7	I: Availability of water sources D: Destruction of water sources
Sanitary (toilet) conditions	3.3	55.0	41.7	I: Hygienic toilets for use D: Higher population, poor
Transport facilities	5.0	33.3	61.7	I: Migration to the city D: Damage to roads
Communication facilities	3.3	51.7	45.0	I: Availability of network D: Disruption in communication
NGO services	15.0	61.7	23.3	I: Good NGO services D: No food program
Institutional credit (banks)	28.3	65.0	6.7	I: Loan from the bank D: Bank not interested
Farm Machinery	21.7	76.7	1.7	I: Government-provided D: Need to buy machinery
Household assets	1.7	83.3	15.0	I: Increase in income D: Sold
Food security condition	91.7	8.3	-	I: Migration to the city D: Loss of land
Availability of labor	1.7	98.3	0	I: No need D: Loss of agricultural land
Marketing facilities	6.7	58.3	35.0	I: Coming near the marketplace D: Not necessary

N.B: I = improved, and D = deteriorated.

3.6. The Riverbank-Erosion-Affected People Migrated Helplessly Leaving Properties

The research respondents were asked fifteen questions about their coping mechanisms for securing food, with the response possibilities being "regularly" (3), "occasionally" (2),

"rarely" (1), and "not at all" (0). Their responses are presented in Table 6. The majority of them (61.7%) mentioned that they migrated to the city when their food security came under threat due to riverbank erosion. The respondents' views on the existence of government and non-government food programs for them are illustrated in Table 5. Among them, 78.3% confirmed that there was no food aid program for those who lost land to erosion in their area. However, 68.3% mentioned that their family members were under government safety net programs. Nevertheless, 93.3% of the participants reported that these programs were inadequate. Furthermore, none of them were under any NGO food program.

Table 6. Coping strategies of the affected people towards food security.

Food Security Strategy	Degree of the Responses (%)			
	Regularly	Occasionally	Rarely	Not at All
Reducing the amount of food per meal	5.0	8.3	10.0	76.7
Reducing the number of meals per day	1.7	1.7	21.7	75.0
Going to bed without food	-	3.3	-	96.7
Relying on less preferred food	5.0	83.3	8.3	3.3
Reducing the purchase of children's food	1.7	76.7	8.3	13.3
Purchasing food on credit	1.7	46.7	35.0	16.7
Borrowing money from NGOs/Government organizations	1.7	16.7	1.7	80.0
Borrowing from moneylenders	6.7	15.0	3.3	75.0
Migrating to a city or another area	61.7	13.3	-	25.0
Relying on casual labor for food	6.7	58.3	1.7	33.3
Selling cattle/livestock	-	83.3	-	16.7
Spending money from savings	1.7	83.3		15.0
Borrowing money or food from	-	73.3	1.7	25.0
Selling land and other assets	-	66.7	3.3	30.0
Selling labor in advance	-	8.3	-	91.7

Note: 3 = Regularly; 2 = Occasionally; 1 = Rarely and 0 = Not at all.

3.7. Local-Government Representative's Initiatives Are Limited

Of the interviewed local government representatives, 85% revealed severe riverbank erosion in their area. The respondents had been representatives for 9.55 years on average. Almost all of them reported that there were food aid programs to ensure food security for the local people, and according to them, on average, 281.80 people were beneficiaries of such programs in their respective areas. When the local government representatives were asked if they had seen any migration tendencies among the affected people in their jurisdiction, almost all of them answered in the affirmative. In addition, they mentioned that, on average, 414.75 affected people had migrated to cities or other places over the previous 5 years commencing in 2015. Regarding strategies to mitigate riverbank erosion in their area, about 65% of the respondents stated that they had action plans, whereas the rest had none (Table 7).

Table 7. Views of local government representatives, and their plans for the affected people.

Questions	Response Category	Response (%)	Mean
Are you a local government representative from the riverbank erosion-affected area?	Yes	85	-
	No	15	
If yes, how many years have you played a role as a local government representative?	-	-	9.55
Do you have any food aid programmes to ensure the food security of local people?	Yes	100	
	No	0	
If yes, how many affected people are beneficiaries of the programmes?	-	-	281.8
Have you seen any migration tendency among the people affected by riverbank erosion in your union area?	Yes	100	
	No	0	
If yes, how many affected people migrated from your union during the last 5 years?	-	-	414.75
Do you have action plans to mitigate riverbank erosion in your area?	Yes	65	

3.8. Inefficient Action Plans for Erosion Control in the Study Area

The study participants mentioned some action plans, which are summarized in Table 8. The local-government representatives were involved in implementing some measures to control riverbank erosion, such as throwing geotextile bags, setting cement concrete blocks and dredging the riverbeds taken by other government agencies. They supported the agencies and motivated local people to participate in the implementation processes. The respondents also mentioned that mitigation plans against riverbank erosion were hindered by a lack of institutional capacity, resource constraints and gaps in coordination among the relevant organizations.

Table 8. Some potential action plans to reduce riverbank erosion in the study area.

Summary of the Respondents' Views of Action Plans, Benefits and Drawbacks	
Action plans	Throwing geo bags
	Dredging river beds
	The setting of cement-concrete (CC) blocks
Benefits of action plans	Saving agricultural land
	Saving agricultural land
	Protecting homestead area
	Improving livelihood Status
	Protecting schools, health centres, gardens, markets, etc.
Drawbacks of action plans	Limited resources
	Local representatives are not entitled to implement big projects with huge budgets
	Lack of coordination among governmental agencies

4. Discussion

In most areas of Bangladesh, riverbank erosion is a common occurrence that impacts about one million people annually [12,39,41]. Besides, riverbank erosion is a serious issue in Bangladesh that annually causes the displacement of millions of people and negatively impacts their psychological well-being [37,46]. The social, physical, and financial conditions in a given area are significantly impacted by riverbank erosion [33]. Additionally, it

increases the vulnerability of marginalized and poor people because of their reduced ability to deal with disasters.

The previous study of river erosion revealed higher male participation (male and female respondents are 23.96% and 9.91%, respectively) in the Koyra upazila in Bangladesh [47]. Our research also showed a similar trend that might be due to religious constraints or that females are not as interested in talking to the interviewer as males are assumed to be the heads of almost all families. Generally, agriculture is the main source of income for Bangladeshi people [48]. In some places, almost half of the household heads engage in fishing as their primary or secondary occupation, specifically in the coastal area [49]. In our study, agricultural crops were the main source of their daily income; maybe they have less opportunity to catch fish or pursue other occupations. Because they lost their land through riverbank erosion, people are now economically very weak, which results in a vulnerable socioeconomic condition.

In the study area, riverbank-erosion-affected people were involved in various occupations, among which agriculture was the main income source for most of them. On the other hand, livestock farming, aquaculture and fishing were insignificant sources of income for them. Furthermore, the income source of many affected people was not specific. The study participants mentioned using a significant portion of their income to purchase food since the majority of them could not produce sufficient food of their own [13,44]. However, many of them were brought under government safety net programs such as Vulnerable Group Feeding, programs to cope with natural disasters and other shocks, and employment generation programs. Bangladesh's status with regard to food availability is seriously threatened by riverbank erosion. Coping is usually a crucial alternative for overcoming this long-term devastation [20]. All of those who responded to the poll, who all resided close to the Padma River, said that riverbank erosion had upset them over the past ten years virtually universally, based on the questionnaire's data. They mentioned that in the affected area, cropland suffered the highest erosion among the different classes of land.

The lives and livelihoods of the people were upset because of the food shortage, destruction of the homestead, decline in income sources, trouble in availing public services and disruption in communication and transportation caused by riverbank erosion. The situation regarding food security varied from month to month. The participants indicated that from January to June, they could secure food, but from July–December, their situation deteriorated [50]. The probable reason behind this is that July–September is the most vulnerable time for crop production, whereas January–March is the safest period for this activity (http://oldweb.lged.gov.bd/ViewMap.aspx, accessed on 1 July 2022).

In terms of household indicators, the majority of the respondents mentioned that their housing condition had deteriorated due to damage to their houses caused by riverbank erosion (http://oldweb.lged.gov.bd/ViewMap.aspx, accessed on 1 July 2022). Regarding their coping strategies for food security, they revealed that when stressed, they migrated to urban areas to earn some extra money. Moreover, some people coped with food scarcity by relying on less expensive or less preferred food items and spending money from their savings [12]. The survey results confirm that in the study area, food aid programs are limited. However, most erosion-affected individuals are covered by government security net initiatives, such as meal-for-work and profit-for-work programs. Such initiatives are implemented by different government organizations. Riverbank erosion has many negative impacts on riverine villagers [16]. However, the respondents in the present study were found to follow some coping mechanisms. In previous studies, researchers have found riverbank erosion-affected people to follow several coping strategies. The important coping strategies they have identified are finding part-time work, treating diseases, undertaking emergency house refurbishment, living on embankments or highlands temporarily and changing occupations [1,3].

The government and non-government institutional setting is very important in the selection of coping options for riverbank-erosion-affected people [45]. The study shows

that local government representatives of the study area have provided some help to the affected people by implementing food aid and safety net programs. However, the number of beneficiaries under such programs is not significant. The representatives indicated in the study that a considerable number of affected people migrated to cities and other places. Further, they mentioned that they had implemented some action plans for protecting people from riverbank erosion. While these schemes were mainly implemented by some other government agencies, they played their role by supporting these initiatives and motivating the local people to help them. However, they also mentioned that they had little capacity to take mitigation steps against riverbank erosion due to resource constraints and a lack of coordination among the relevant organizations.

Lastly, besides outside support, the traditional knowledge and skills of the locals are important factors that may significantly help them overcome the challenges posed by natural disasters. This argument is supported by Islam et al., who stated that an appropriate system for forecasting the water flow of rivers and floods and the integration of local techniques and modern technologies can help reduce the impacts of riverbank erosion [23].

5. Conclusions

Riverbank erosion is the most common natural disaster in riverine Bangladesh. According to the present research, in the Zanjira sub-district of Shariatpur district, a densely populated area, most of the people, who are also poor and marginalized, are affected by this natural disaster. Many even lose their entire homestead. Therefore, in many cases, people migrate to urban areas. Due to the loss of their farmlands, their agricultural production is decreasing day by day. Moreover, their purchasing capacity is quite low because of the lack of other income sources. Thus, they are regularly affected by food scarcity, especially during July–December. Consequently, almost all people are anxious about a shortage of food, though the number of hungry locals is quite small in the study area. While many residents have been brought under the social safety net and food aid programs of the government, these are not sufficient to help all the affected people.

Besides the government's initiatives, the distressed locals follow some coping mechanisms during stressful situations. Others cope with food scarcity by relying on less expensive or less preferred food items and spending money from their savings. The local government representatives also play their part in assisting the riverbank-erosion-affected people through government schemes. Overall, in order to protect local people's lives, the river, and Bangladesh's natural environment, it is urgent to reduce riverbank erosion with the cooperation of the government and non-government organizations. To ensure people's socioeconomic standing, it is necessary to promote current technology and create new strategies for minimizing riverbank erosion.

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